Options Analysis Report

NORTH RUSTICO FIRE HALL OPTIONS ANALYSIS

Town of North Rustico

Canadian Urban Institute

EastPoint Reference No. 354002

EASTPOINT

Prepared for:

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ENGINEERING SERVICES FOR

North Rustico Fire Hall - Options Analysis Consulting Services

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June 12, 2025

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EXECUTIVE SUMMARY

The Canadian Urban Institute engaged EastPoint on behalf of the Town of North Rustico to conduct an options analysis of up to five different mechanical system configurations for the new Fire Hall building being proposed on Timber Lane.

The objective of this study was to:

- Establish baseline for analysis of estimated energy consumption.
- Recommend up to five options that have the best potential to meet the Town's objectives.
- A high-level comparison of each option highlighting trade-offs between cost, effectiveness, and feasibility.
- Identify funding avenues for the Town to pursue in the construction of this facility.

A preliminary options report was delivered by EastPoint on March 31, 2025, identifying the five options to be pursued for analysis. This preliminary report identified the six options to be analyzed in detail as:

- Option 1 - Propane Fired Indoor Furnaces.
- Option 2 - Ducted Heat Pump Furnaces with Propane Backup.
- Option 3 - Heat Pump Primary with Biomass Boiler Backup.
- Option 4 - Ducted Heat Pump Furnaces with Electric Backup and Heat Recovery Ventilation.
- Option 5 - Option 4 with Solar Photovoltaic Add-on.
- Option 6 - Geothermal Heat Pump with Electric Backup and Heat Recovery Ventilation.

Following the analysis of each option identified, **EastPoint recommends Option 5** consisting of ducted heat pumps with backup electric, heat recovery ventilation, and solar photovoltaic be pursued for the proposed facility. Given this option is fully electric, emissions are expected to be reduced even further than projections made in this report as the electricity grid becomes less emission intense. If the Town is planning to install high-capacity wells on site for rapid fire truck filling, **EastPoint also recommends strong consideration of the geothermal system**, as it can leverage the same well infrastructure for its heat source. This system is also fully electric, offering all the same long-term emissions and energy cost benefits as Option 5, with only a modest increase in upfront investment. If the Town of North Rustico would rather have on-site combustion for heating to reduce generator requirements and overall implementation costs, **EastPoint recommends Option 2 as low-cost alternative.**

EastPoint also identified various funding avenues which the Town may be able to access in the construction of this new facility. **EastPoint identified the Green Municipal Fund** by the Federation of Canadian Municipalities as a promising funding stream for the Town given the projects alignment with program eligibility requirements. Additional programs that should be further explored for potential funding include the Rural Growth Initiative (Community Revitalization) by the Government of Prince Edward Island, and the PEI Climate Challenge (CC) Fund delivered by the province. Further details regarding eligibility to these programs and potential funding available is presented in Section 1.3.

Each of the six options consists of its own advantages and disadvantages that were considered during analysis. These considerations, in addition to forecasted energy consumption and implementation costs, were used for identifying the optimal solution for the Town of North Rustico. A summary of the advantages and disadvantages of each option is presented in the table below. Further discussion regarding the benefits and shortcomings of each option is presented in Section 4 of the report.

Table 1: Summary of Advantages & Disadvantages of All Options

	Option 1 - Propane Fired Indoor Furnaces	**Option 2 -** Heat Pump (HP) Furnaces with Propane Backup	**Option 3 -** HP Furnaces with Biomass Backup	**Option 4 -** HP Furnaces with Electric Backup	**Option 5 -** HP Furnaces with Electric Backup + Solar PV	**Option 6 -** Geothermal Heat Pumps
Advantages	• Lowest implementation cost. • Smaller generator required.	• Low implementation cost. • Smaller generator required. • Attractive payback from incremental investment.	• Low emissions (if biomass emissions excluded).[1] • Smaller generator required (on-site combustion heating).	• Lowest Energy Usage Intensity (EUI). • High potential for low emissions as grid becomes cleaner.	• Lowest annual energy costs. • Lowest GHG emissions. • High potential for even lower emissions as grid becomes cleaner. • Economical investment long term.	• Low annual energy costs. • Low GHG emissions. • High potential for even lower emissions as grid becomes cleaner. • Can draw source from fire truck refill well, if planned.
Disadvantages	• High GHG emissions. • Highest annual energy costs. • Limited funding streams available.	• Mid-high GHG emissions. • Mid-high annual energy costs.	• Very high implementation costs. • High emissions (if biomass emissions included). • Potential serviceability issue.	• Larger generator required (electric heating system). • Emissions remain relatively high given current grid emissions factor.	• High implementation costs. • Larger generator required (electric heating system).	• Higher implementation costs. • Larger generator required (electric heating system).

[1] Biogenic emissions do not count towards Scope 1 & 2 emissions due to their decomposition and thus carbon release being considered a natural part of the earth's carbon cycle by the government. They have been included in this analysis for transparency, however, may not be required for GHG emissions accounting in the future.

These options were developed to consider heating, ventilation, and Domestic Hot Water (DHW) requirements for the proposed building. The proposed implementation costs are rough order of magnitude estimates for all heating, ventilation, and DHW systems. The proposed energy consumption for each option represents all energy consumption anticipated for the facility (includes addition of lighting and plug loads). The energy model used for analysis was developed applying National Energy Code of Buildings (NECB) standards for estimating occupant load and usage. The results of this analysis for each option are presented in the table below.

Table 2: Summary of Forecasted Energy Consumption & Implementation Costs of All Options

Option	Annual Energy Consumption[2] (ekWh)	Peak Electrical Demand (kW)	Annual Energy Costs ($)	Implementation Costs ($)	Annual Emissions (tCO_2)
1	242,908	22.0	37,753	222,000	57.7
2	206,587	24.7	33,436	225,000	52.5
3	225,298	23.9	31,320	303,500	70.3
4	184,411	87.8	34,986	240,000	55.3
5	116,749	87.8	24,872	435,000	35.0
6	190,533	66.2	35,031	291,300	57.2

[2] Total annual facility consumption including electricity consumption and any on-site fossil fuel combustion. Energy consumption by fuel source for each option is presented in Section 4 & 6 of this report.

1 CONTEXT & METHODOLOGY

The Canadian Urban Institute (CUI) commissioned EastPoint on behalf of the Town of North Rustico to conduct an options analysis for a new Fire Hall on a municipal site that currently hosts their wastewater treatment plant.

This report presents EastPoint's analysis of five different options that were explored in detail through energy modelling and rough order of magnitude cost assessment. These options were originally presented to the Town of North Rustico for approval in a preliminary options report delivered on March 31, 2025. In addition to estimated implementation costs and energy consumption of these various system options, this report elaborates on the advantages and disadvantages of each system configuration.

1.1 Background

The Town of North Rustico's current volunteer Fire Department Fire Hall is in a flood risk zone. This was made evident when the facility flooded with more than a foot of water during Hurricane Fiona in September of 2022, as summarized in the recent adaptation study delivered to the Town in 2023/24. North Rustico is now exploring options to build a new Fire Hall on a municipal site that currently hosts the Town's wastewater treatment plant.

This proposed site is a former municipal landfill, which raises concerns of both soil stability and subsidence, and methane management, as well as other potential sources of contamination on the site. Test pit results from Stantec conducted in 2013 were shared with EastPoint to understand known information regarding the state of the former landfill. EastPoint understands that North Rustico is pursuing further geotechnical investigations to determine the feasibility of new construction at the identified site.

1.2 Client Information

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1.3 Project Drivers

The Town of North Rustico is seeking assistance in developing a framework for analyzing various options of heating and ventilation systems for their proposed new Fire Hall. The Town has indicated they wish to have the facility as near to Net-Zero as possible from a Greenhouse Gas (GHG) emissions perspective, while still being economically feasible to build and operate.

EastPoint has identified potential funding avenues that the Town could leverage during the design and construction of this new facility. Potential funding avenues and initial assessment of their eligibility requirements include:

- **Green Municipal Fund** - Program by the Federation of Canadian Municipalities that offers combined grant and loan for up to 80% of eligible costs up to a maximum of $10 million for construction of new sustainable Municipal and community buildings:
  - Proposed building's Energy Usage Intensity (EUI)[3] must be 25% lower than NECB 2020 baseline.

[3] Energy Usage Intensity (EUI) represents the annual total energy consumption of a facility divided by it's total area, often presented in units of kWh/sf.

  - Proposed building's Thermal Energy Demand Intensity (TEDI)[4] must be equal or better than NECB 2020 baseline.

- **Rural Growth Initiative, Community Revitalization** - Multiple funding steams available for municipalities, including the following:
  - *Small-scale projects* - Maximum contributions of 75% up to $250,000 of total eligible costs.
  - *Large-scale projects* - Maximum contribution of 50% up to $2 million of total eligible costs.
  - *Heat Pump Initiative* - One-time assistance of 100% of heat pump costs up to a maximum of $20,000.
  - *Reception Centre Resiliency Program* - Maximum contribution of 80% up to $250,000 of eligible costs.
- **PEI Climate Challenge (CC) Fund** - Program delivered by the Provincial Government available to municipalities for projects that align with the goals and objectives of *2040 Net Zero Framework* and the *Building Resilience: Climate Adaptation Plan*. CC Fund contributions of up to $100,000 per project are available.

2 PROCESS

2.1 Kick-Off Meeting

A kick-off meeting was held between EastPoint's Kirk Herman, Ryan Cooke, and Liam Carson, CUI's Dan Wassmansdorf, and North Rustico's Stephanie Moase on Monday, March 24, 2025. The purpose of this meeting was to define North Rustico's energy efficiency and GHG emissions reductions in the design of the new firehall.

2.2 Preliminary Design Concept

The Town of North Rustico is currently collaborating with the Fire Department to identify wants and needs of the new facility. All information provided to EastPoint regarding this preliminary design concept is summarized within this section. The options analysis performed will consider this information to provide the optimal solution for the Town of North Rustico and Fire Department.

2.2.1 Floor Plans

The North Rustico Fire Department has provided the Town of North Rustico with initial concept drawings of the proposed Fire Hall. This conceptual design is comprised of a high bay garage space with seven overhead doors, a boardroom, a kitchen, an office, and a utility room. The total square footage in the plans presented is 12,166 sqft. This floor plan will be used for the development of various options of mechanical systems for the new Fire Hall. The referenced floor plans are presented in **Figures 1, 2, and 3.**

[4] Thermal Energy Demand Intensity (TEDI) represents the annual total *heating* energy consumption (including space and ventilation heating) of a facility divided by it's total area, and is often presented in units of kWh/sf.

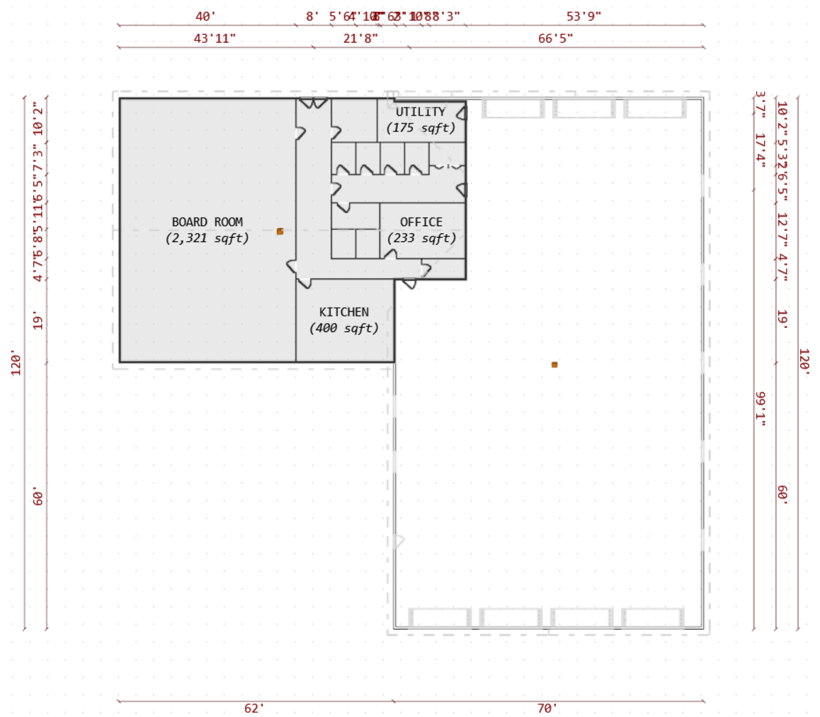

Figure 1 - Concept Floor Plan of Full Facility

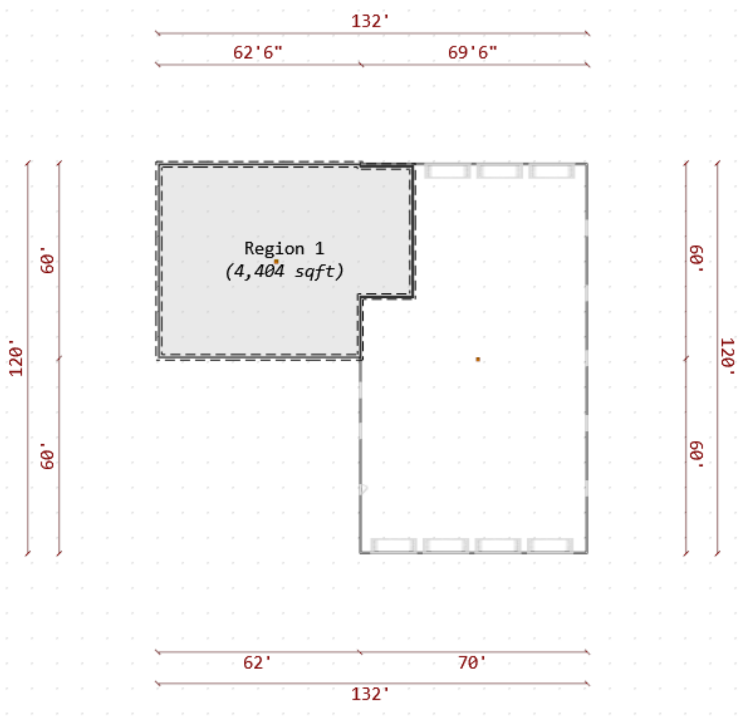

Figure 2 - Office Portion Floor Area

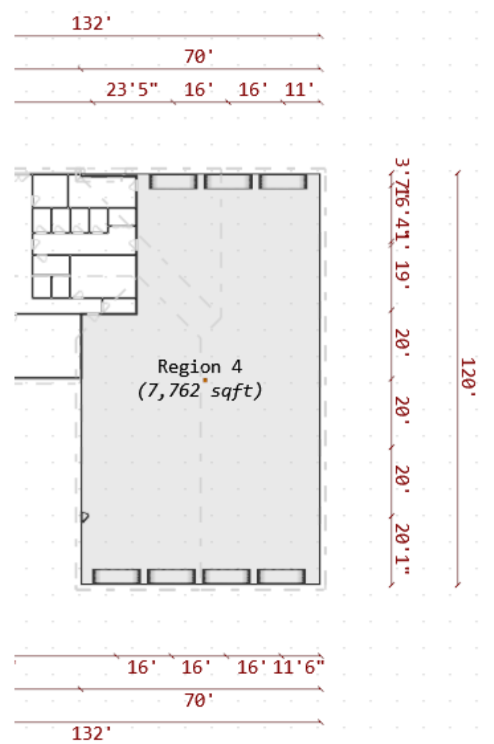

Figure 3 - Garage Portion Floor Area

2.2.2 Comparable Existing Building - New London Fire Hall

The Town of North Rustico identified the New London Fire Hall as a building that may serve as an example of a facility that meets the requirements of the Fire Department while also being feasible for the Town. Preliminary investigation by EastPoint identifies that the most recent construction on this building occurred in 2009.

Figure 4 - New London Fire Hall (Google Streetview, Captured 2024)

Desktop review of available site photos suggest the building uses an oil-fired primary heating source (based on visible chimney) and air-sourced heat pumps. Domestic Cold Water (DCW) is supplied by a well visible at the front of the building, and propane tanks on the northeast corner of the building suggest a generator set is present for emergency power. Ventilation grilles on the outside indicate building is equipped with ventilation system.

2.3 Utility Analysis

To forecast expected utility costs for each of the proposed systems, the utility rate of each energy source must be accurately defined. The most recent utility rates applicable to the proposed Fire Hall building are provided in **Tables 3 and 4.** The emission intensity of these fuel sources must also be considered to assess the potential emissions at this site. The emission factors to be used in this study have been provided in **Table 5.**

Table 3: Utility Rates - Electricity[5]

Service Charge ($ per Billing Period)	Demand Charge ($/kW per Billing Period)		Consumption Charge ($/kWh per Billing Period)	
24.57	First 20 kW	0.00	First 5,000 kWh	0.2113
	Remaining Balance	13.43	Remaining Balance	0.1389

[5] Electricity rates for general service retrieved from Maritime Electric as set under the provisions of the Prince Edward Island Electric Power Act.

Table 4: Utility Rates - Fuel[6]

Fuel Source	Fuel Rate ($/L)
Propane	0.96 (0.13 $/ekWh)
Fuel Oil	1.16 (0.11 $/ekWh)
Wood Pellets	7.48 $/40 lb bag (0.09 $/ekWh)

Table 5: Emission Factors

Energy Source	Emissions (GCO_2/ekWh)
PEI Electricity Grid	300
Propane	210
Fuel Oil	250
Wood Pellets (Biogenic)	320[7]

The Government of Canada reports that Prince Edward Island has an estimated total electricity generating capacity of 441 megawatts. Roughly 99% of power generation on PEI is from wind farms, which is a source of electricity with very low GHG emissions. However, PEI's emissions factor is higher than anticipated when assessing generating stations due to the large amount of electricity imported from the province of New Brunswick. The resulting consumption emission intensity presented in **Table 5** was retrieved from the Government of Canada's Department of Environment and Climate Change's Emission Factors and Reference Values report for Canada's Greenhouse Gas Offset Credit System, published in 2024.

There are discussions within the energy industry regarding the accounting of emissions from biomass fuel sources. The emissions presented in **Table 5** show the actual emissions measured during the combustion of wood pellets. However, the Federal Government does not require accounting of these emissions as part of Scope 1 & 2 emissions. This is because of the natural cycle of biomass degradation, which results in the emission of this carbon to the atmosphere even if these resources are not used for combustion. Therefore, emissions from this fuel source will not be presented when comparing the various options, however, should be recorded separately for transparency.

2.4 Energy Benchmark

An energy benchmark for an existing facility can be represented by Portfolio Manager's reference Energy Usage Intensity (EUI) for buildings of this type (fire halls). Given the anticipated occupancy of this new fire hall (volunteer, sparsely occupied) relative to the occupancy of this reference (24/7), the expected energy consumption for the proposed Fire Hall is less than this reference. Nonetheless, this value is a useful benchmark for comparison and analysis of all proposed options.

[6] Petroleum product pricing retrieved from the Island Regulatory & Appeals Commission (IRAC) updated as of March 21, 2025. Wood pellet pricing retrieved from Kent Building Supplies.

[7] Biogenic emissions do not count towards scope 1 & 2 emissions due to their decomposition and thus carbon release being considered a natural part of the earth's carbon cycle by the government. They have been included in this analysis for transparency, however, may not be required for GHG emissions accounting in the future.

Table 6: Reference Building Energy Baseline

Reference EUI	Floor Plan Area	Reference Building Energy Consumption
17.0 ekWh / sf	12,166 sf	**207,214 ekWh**

3 ENERGY MODEL

3.1 Modelling Software

A detailed analysis of the proposed systems was performed using Carrier's Hourly Analysis Program (HAP) Version 6.2. The proposed floor plans were used to create a 3D space model within the software which was subjected to thermal analysis for all full year consisting of 8,760 hours. The figure below shows a 3D representation of the space subjected to analysis. Building energy consumption was modelled based on National Energy Code for Buildings (NECB) 2020 guidelines, which are further discussed in Sections 3.3 and 3.4. Financial and GHG analysis was performed in Microsoft Excel using the factors presented in Section 2.3. The solar resource analysis was performed using NRCan's RETScreen software.

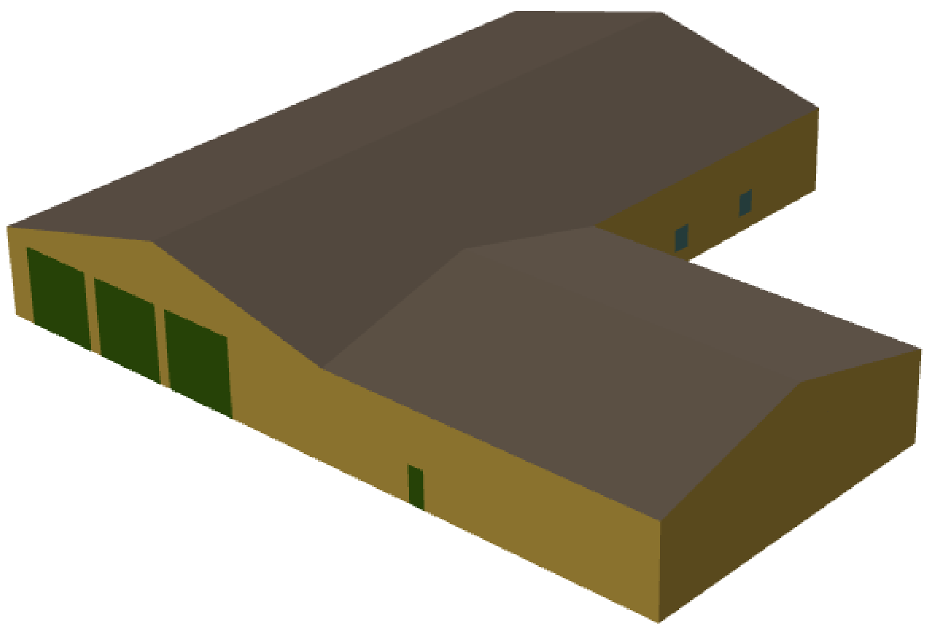

Figure 5 - Space Model of Proposed Fire Hall Using Carrier's HAP Software

3.2 North Rustico Climate Zone

Heating Degree Days are defined as the number of degrees that a day's average temperature is below the base temperature which the building needs to be heated summed over the course of an entire year. The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) has defined different climate zones based on how many HDD the region experiences on average per year. North Rustico HDD for the 2024 calendar year totalled 4,650, placing it in Climate Zone 6.

Table 7: ASHRAE Climate Zone by HDD

	Zone 4	Zone 5	Zone 6	Zone 7A	Zone 7B	Zone 8
HDD	< 3,000	3,000 to 3,999	4,000 to 4,999 **(NR – 4,650)**	5,000 to 5,999	6,000 to 6,999	≥ 7,000

3.3 Building Envelope

The building envelope assemblies modelled for the proposed Fire Hall used the minimum thermal requirements for compliance with NECB 2020. Values associated with ASHRAE Climate Zone 6 (4,000 - 4,999 HDD) were used for this analysis. All options explored were modelled using equivalent envelope conditions to compare mechanical system performance.

3.3.1 Opaque Assemblies

The thermal performance of the material used to construct the building will directly impact overall energy consumption of the facility. The thermal properties modelled for wall, roof, and floor assemblies for the proposed Fire Hall are presented in **Table 8**. Furthermore, given the Town's expressed interest in pursuing an Insulated Concrete Form (ICF) foundation, thermal properties of an ICF foundation were incorporated into the energy modelling to reflect this design intent and ensure accurate performance projections.

Table 8: Thermal Performance of Opaque Building Assemblies

Assembly	NECB Minimum Thermal Transmittance, U-Value (W/m^2K)	Equivalent Thermal Resistance, R-Value ($hrft^2°F/BTU$)
Walls	0.240	23.6
Roof	0.138	41.1
Floors	0.757	7.5

3.3.2 Penetrations

The thermal performance of building penetrations will also impact the overall energy consumption of the facility. The thermal properties modelled for windows and doors for the proposed Fire Hall are presented in **Table 9**.

Table 9: Thermal Performance of Building Penetration Assemblies

Assembly	NECB Minimum Thermal Transmittance, U-Value (W/m^2K)	Equivalent Thermal Resistance, R-Value ($hrft^2°F/BTU$)
Windows	1.73	3.3
Doors (Overhead & Man Doors)	1.90	3.0

3.3.3 Air Leakage

Any air entering the facility will increase overall energy consumption required due to the additional energy required to heat that air. In addition to mechanical ventilation, buildings are susceptible to an additional natural air infiltration. Rates of air infiltration can be determined through means of building pressurization testing, which measure how much air enters the facility when the building is subjected to a known pressure. For this analysis, standard NECB guidelines were applied, resulting in a natural air infiltration rate of approximately 1 Air Change per Hour (ACH).

3.4 Ventilation Requirements

To determine ventilation requirements for the facility, ASHRAE 62.1 Standards for Indoor Air Quality (IAQ) were used. This standard determines how much outdoor (fresh) air is required for each zone in the building based on space type, size, and expected occupancy. Further consideration was given to the garage space to identify how much exhaust is required when vehicles are operated, as well as base ventilation rates required for the space when occupied. The ventilation rates determined and used within this analysis are presented in **Table 10** below.

Table 10: Proposed Fire Hall Outdoor Air Requirements

Zone	Floor Plan Area (ft^2)	Minimum Outdoor Air Required (CFM)
Region 1	4,404	924
Region 2 - Base Ventilation	7,762	466
Region 2 - Vehicle Exhaust[8]	7,762	11,643

3.5 Occupancy & Equipment Schedules

Modelling of building occupancy behaviour was performed using NECB 2020 Operating Schedule F which is representative of Fire Hall occupancy. These schedules are used to define the usage intensity of lights, electrical equipment (plug loads), and Domestic Hot Water of the facility at all times of the time. Furthermore, occupant density of the building will impact space heating and cooling requirements of the space. These usage schedules are represented as a fraction of the peak load for the facility. The fractional occupancy schedule for people, lights/plug loads, and Domestic Hot Water are presented in **Tables 11, 12, and 13.**

[8] Required ventilation to remove contaminants related to vehicle exhaust within the garage, typically operated from a CO/NOx detector.

Table 11: NECB Occupant Fractional Operating Schedule F (Applicable to Fire Halls)

Fractional Occupant Schedule																								
Hour	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Mon - Fri	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6
Sat	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6
Sun	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6

Table 12: NECB Lighting & Plug Load Operating Schedule F (Applicable to Fire Halls)

Fractional Lighting & Plug Load Schedule																								
Hour	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Mon - Fri	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.4	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.6	0.6	0.6	0.4	0.2
Sat	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.4	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.6	0.6	0.6	0.4	0.2
Sun	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.4	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.6	0.6	0.6	0.4	0.2

Table 13: NECB Service Water Load Schedule F (Applicable to Fire Halls)

Fractional Domestic Water Heating Schedule																								
Hour	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Mon - Fri	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.4	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.6	0.6	0.6	0.4	0.2
Sat	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.4	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.6	0.6	0.6	0.4	0.2
Sun	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.4	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.6	0.6	0.6	0.4	0.2

3.6 Temperature Setpoints

The temperature setpoint in each space will impact the overall energy consumption of the facility. Given the anticipated fluctuating occupancy of the facility, programmable thermostats with occupied and unoccupied setpoints to be enabled based on a Time of Day schedule should be implemented to reduce the temperature setpoint when the building is unoccupied. The following setpoints have been used for modelling the spaces based on NECB requirements for the zones.

Table 14: Temperature Setpoints Used for Modelling

Zone	Occupied Heating (°C)	Unoccupied Heating (°C)	Occupied Cooling (°C)	Unoccupied Cooling (°C)
Region 1	22	18	22	26
Region 2	18	18	N/A	N/A

4 ANALYSIS OF OPTIONS

4.1 Option 1 - Propane Fired Indoor Furnaces with Air Conditioning

The primary objective with this option is to minimize total implementation costs while meeting functional requirements to ensure occupant comfort and building code compliance.

4.1.1 Description of Systems

Building Space Heating

For this option, the space temperature in both the office and garage spaces would be conditioned by ducted propane fired indoor furnace units. The unit serving the kitchen, office, and boardroom area (Region 1) would also be equipped with direct expansion cooling for air conditioning. These units would have one thermostat each that would be wall mounted in the space they serve. The thermostat would allow occupants to set heating and cooling temperature setpoints. This configuration would likely consist of one unit serving Region 1, and a second unit serving the garage space (Region 2). Additional ceiling mounted propane fired unit heaters in Region 2 may be included to satisfy the entire heating load.

Ventilation

Ventilation for this option would be served by the ducted units presented for building space conditioning. These units would bring in a certain fraction of outdoor air (typically 10 - 30%) that would mix with return air to provide ventilation for the space. Initial sizing based on ASHRAE 62.1 Indoor Air Quality (IAQ) standards will be determined as a basis for energy calculations within this analysis. In addition to the proposed units, the garage would also be equipped with a larger exhaust fan that is programmed to run when combustion gas exceeds a certain concentration in the space. Further consideration will also be given to tailpipe exhaust, with a hose reel system to be installed to operate vehicles indoors.

Domestic Hot Water

For this option, electric Domestic Hot Water (DHW) tank(s) would be located in the utility room to generate hot water for the facility. Propane fired DHW tanks are also an option. They typically have greater capacities, however, can be a more costly alternative to residential-style electric water heaters. The most cost-effective solution will be provided during the analysis phase.

Figure 6 - Ducted Indoor Furnace Example

4.1.2 Analysis of Option

The primary benefit of this option is the lowest implementation cost to deliver space heating and ventilation for the facility. Furthermore, given this option includes an on-site combustion heating option, which means that a smaller generator could be used if the site is required to be used as a warming centre. Despite these benefits, the on-site combustion also results in high GHG emissions relative to alternative options, the highest annual energy costs of the proposed list, as well as potential risks with accessing funding through green building funding streams. A summary of these pros and cons are presented in **Table 15**.

Table 15: Option 1 - Advantages & Disadvantages

Advantages	Disadvantages
• Lowest implementation cost. • Smaller generator required (gas heating).	• High GHG emissions. • Highest annual energy costs. • Limited funding streams available.

In order to assess potential benefits and impacts of investing further to satisfy GHG and energy reduction initiatives, it is important to compare the proposed energy consumption of each option against a baseline operation of the building. Option 1 will act as the baseline for comparison of all options as it is the lowest implementation cost option and will allow for clear comparison of benefits achieved for incremental cost pursued. The modelled energy consumption and estimated implementation costs of Option 1 are presented in the table below.

Table 16: Comparison of Option 1 to Baseline

Option	Propane Consumption (L)	Electricity Consumption (kWh)	Peak Electrical Demand (kW)	Energy Costs ($)	Emissions (tCO_2)	Implementation Costs ($)
Baseline (Option 1)	**23,560**	**75,088**	**22.0**	**37,753**	**57.7**	**222,000**

4.2 Option 2 - Ducted Heat Pump Furnaces with Propane Backup

This option presents the low implementation cost focused systems of Option 1, with minor investment to make these systems more energy efficient.

4.2.1 Description of Systems

Building Space Heating

Option 2 consists of the same systems presented in the first option, however, rather than direct expansion (cooling only) air conditioning, these units would feature heat pump coils that can provide high efficiency heating and cooling. The benefit of using a heat pump as the primary source of heating is that it is far more efficient than traditional combustion based systems. The Coefficient of Performance (COP) of a heat pump is a metric used to determine a system's efficiency, and it is defined as heating output divided by electrical energy input. Air Sourced Heat Pumps (ASHP) typically have COPs of 2 - 3, resulting in comparable efficiencies of 200% - 300%. A restraint of these systems is that the total heating capacity decreases as the outdoor air temperature drops. These systems therefore require a back-up source of space heat to serve the building during the few occasions per year that the heat pump cannot deliver all space heating required. When back-up heating is required, the propane burner would meet these requirements.

Ventilation

From a ventilation perspective, this option is exactly the same as Option 1. The indoor furnace units would provide base ventilation requirements, and a larger exhaust system would be included in the garage space to exhaust combustion gases when they meet a certain concentration in the space. Further consideration will also be given to tailpipe exhaust, with a hose reel system to be installed to operate vehicles indoors.

Domestic Hot Water

This option includes the same DHW system presented in Option 1. Electric DHW tank(s) would be located in the utility room, with consideration held to explore a propane fired option. The most cost-effective solution will be provided during the analysis phase.

Figure 7 - Ducted Heat Pump With Propane Backup Example

4.2.2 Analysis of Option

This option is similar to Option 1, with the additional investment of heat pumps to serve as primary heating to reduce energy consumption. This option also incurs the benefit of requiring a smaller back-up generator, as the propane heating system will be able to serve all space heating needs in the event of a power outage. Given on-site fossil fuel combustion is still present with this option, it also incurs relatively high GHG emissions and energy costs. A summary of these pros and cons are presented in the table below.

Table 17: Option 2 - Advantages & Disadvantages

Advantages	Disadvantages
• Low implementation cost. • Smaller generator required (gas heating). • Attractive payback from incremental investment.	• Mid-high GHG emissions. • Mid-high annual energy costs.

Table 18: Comparison of Option 2 to Baseline

Option	Propane Consumption (L)	Electricity Consumption (kWh)	Peak Electrical Demand (kW)	Energy Costs ($)	Emissions (tCO_2)	Implementation Costs ($)
Baseline (Option 1)	23,560	75,088	22.0	37,753	57.7	222,000
Option 2	**14,671**	**102,084**	**24.7**	**33,436**	**52.5**	**225,000**

4.3 Option 3 - Heat Pump Primary with Biomass Boiler Secondary

This option is focused on presenting an option with a biomass fuel source due to potentially advantageous GHG emissions reporting as discussed in Section 2.3.

4.3.1 Description of Systems

Building Space Heating

For this option, a biomass boiler that uses wood pellets would be located in the utility room to generate hot water for a hydronic distribution. This boiler would generate 90 - 110 °F (32 - 43 °C) supply water. This water would be circulated to an in-floor distribution using circulator pumps. This system would consist of two zones, one for the boardroom, office, kitchen area (Region 1), and one for the garage space (Region 2). Each zone would be controlled by a wall mounted thermostat.

In addition to this system, heat pumps would be installed to serve as the primary heating source (ducted in the office, wall mounted in the garage). As described in Option 2, heat pumps are a preferred source of primary heat due to their greater efficiency. These heat pumps would deliver heat to the spaces from heat extracted outside using exterior condensing units ground mounted around the facility.

Ventilation

Ventilation air for the office spaces would be ducted from the outdoors directly to the ducted heat pumps, which will condition the air (heat or cool) prior to delivering it to spaces. Exhaust fans in the washroom operating from light toggle switches will be used to exhaust these spaces. Fresh air will be directly ducted into the garage space, which would have three exhaust systems including: one small fan providing ventilation for the occupants of the garage when the lights are on, one larger fan connected to the gas detection system to start the fan if vehicle exhaust gas concentrations are too high, and one exhaust unit direct with flex hoses to the fire truck tailpipes.

Domestic Hot Water

This option will include an indirect tank coupled to the biomass hydronic system to generate DHW for the facility. This tank is to be located in the same mechanical room housing the biomass boiler. In addition, further analysis of a hybrid ASHP/electric tank located in the mechanical room will be explored as it may be a suitable alternative given the potential waste heat available from the boiler.

Figure 8 - Vacuum Suction Wood Pellet Boiler Example

4.3.2 Analysis of Option

Similar to Option 2, this option will consist of a heat pump primary heating source with on-site combustion as a secondary heating source when required. Due to this similarity, this option will have comparable benefits of lower energy intensity relative to full combustion heat, but with the benefit of a smaller generator being required given full sized boiler backup. However, biomass boilers require significant investment given high implementation costs for both material and labour. Furthermore, any additional servicing required may be subject to high mobilisation costs given the system complexity and rarity. A summary of these pros and cons are presented in the table below.

Table 19: Option 3 - Advantages & Disadvantages

Advantages	Disadvantages
• Low emissions (if biogenic emissions ignored). • Smaller generator required (on-site combustion heating).	• High implementation costs. • High emissions (if biogenic emissions considered). • Potential serviceability issue.

Table 20: Comparison of Option 3 to Baseline

Option	Propane Consumption (L)	Biomass Consumption (lbs)	Electricity Consumption (kWh)	Peak Electrical Demand (kW)	Energy Costs ($)	Emissions (tCO_2)	Implementation Costs ($)
Baseline (Option 1)	23,560	0	75,088	22.0	37,753	57.7	222,000
Option 3	**0**	**64,472**	**89,394**	**23.9**	**31,320**	**70.3**[9]	**303,460**

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[9] EastPoint has included biogenic emissions for transparency. If excluded, total emissions for this system are 26.8 tCO_2.

4.4 Option 4 - Ducted Heat Pumps with Electric Backup and Heat Recovery Ventilation

This option presents a bundle of mechanical systems that optimize energy efficiency and help realize the Town's objectives of constructing a facility with climate resilience, low operating costs, and low GHG emissions.

4.4.1 Description of Systems

Building Space Heating

Similar to Options 1 & 2, this option will deliver heating through forced air means. This proposed system would include ducted heat pumps to serve heating and cooling requirements, each equipped with an electric coil backup to meet heating requirements when the outdoor air temperature exceeds the operating conditions of the heat pumps. The optimal solution would likely include one system for the boardroom, office, kitchen area (Region 1), and a second system for the garage area (Region 2). To further enhance energy efficiency in Region 2, mini-split heat pumps and/or wall-mounted unitary packaged heat pumps will be installed. This will increase total heat pump capacity in this space, reducing overall energy consumption from electric resistive back-up sources.

Ventilation

Ventilation air for Region 1 would be provided using an Energy Recovery Ventilator (ERV) to supply fresh air to the heat pump. The ERV system will recover heat from the exhaust air stream and deliver it to the incoming supply air to reduce total fresh air heating costs. Ventilation for the garage would be provided by three systems including: One small ERV providing continuous ventilation for occupants during the day, one larger fan connected to the gas detection system to start the fan if combustion exhaust gas concentrations are too high, and one exhaust unit direct with flex hoses to the fire truck tailpipes.

Domestic Hot Water

This option will include standard electric DHW tanks with sufficient capacity to meet the needs of the facility. A propane fired tank will not be explored, as propane is not used for any other systems in this option. This tank will be located in the utility room.

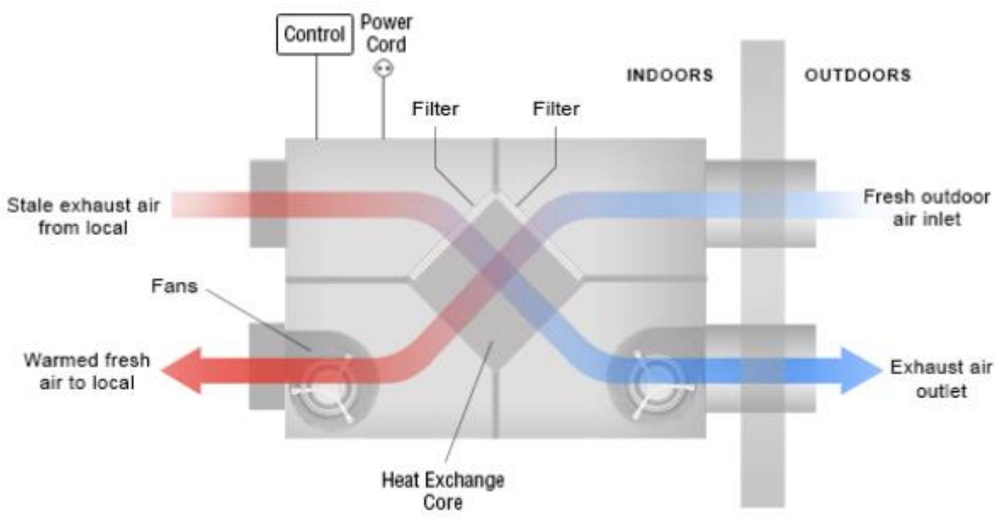

Figure 9 - Heat Recovery Ventilator Diagram (Retrieved from Airtecnics)

4.4.2 Analysis of Option

Thanks to the addition of an Energy Recovery Ventilator (ERV) to this bundle, this package features the lowest annual energy consumption (before renewable offsets). This option is fully electric, resulting in somewhat elevated emissions in the baseline year, but yields the greatest possibility for achieving full net-zero within the life of this building as grid emissions are reduced. However, an electric heating source will require a full sized diesel-powered commercial generator capable of meeting all electrical requirements for space heating in the event of a grid outage. A summary of these pros and cons are presented in the table below.

Table 21: Option 4 - Advantages & Disadvantages

Advantages	Disadvantages
• Lowest Energy Usage Intensity (EUI). • High potential for low emissions as grid becomes cleaner.	• Larger generator required (electric heating system). • Emissions remain relatively high given current grid emissions factor.

Table 22: Comparison of Option 4 to Baseline

Option	Propane Consumption (L)	Electricity Consumption (kWh)	Peak Electrical Demand (kW)	Energy Costs ($)	Emissions (tCO_2)	Implementation Costs ($)
Baseline (Option 1)	23,560	75,088	22.0	37,753	57.7	222,000
Option 4	**0**	**184,411**	**87.8**	**34,986**	**55.3**	**240,000**

4.5 Option 5 - Heat Pumps, ERVs, and Solar Photovoltaic

4.5.1 Description of Systems

This option will analyze all of the systems presented in Option 4, with an additional component of analyzing optimal solar Photovoltaic (PV) implementation. This option will explore potential for roof mounted and ground mounted solar arrays and estimate rough order of magnitude potential electricity offsets. The solar PV analysis has been added to the fully electric building option given the larger electrical consumption available to offset, however, these results could be extrapolated and applied to any of the other four options.

4.5.2 PV Analysis

Using the proposed site, floor plans and a typical roof slope, EastPoint modelled the total solar PV electricity generation feasible from a roof mounted configuration. The optimal configuration for roof mounted determined would be two arrays, taking advantage of the most southern facing roof areas. Modelling of these roof areas identified that a 40 kW array with a slope of 14° and an azimuth[10] of 68°, as well as a 17 kW array with a slope of 14° and an azimuth of 22° could be installed. A rendering of the proposed solar configuration is shown in the figure below. The table below presents the forecasted energy savings and implementation cost of the solar PV installation presented. These numbers are then added to Option 4 to complete the overall Option 5 recommendation.

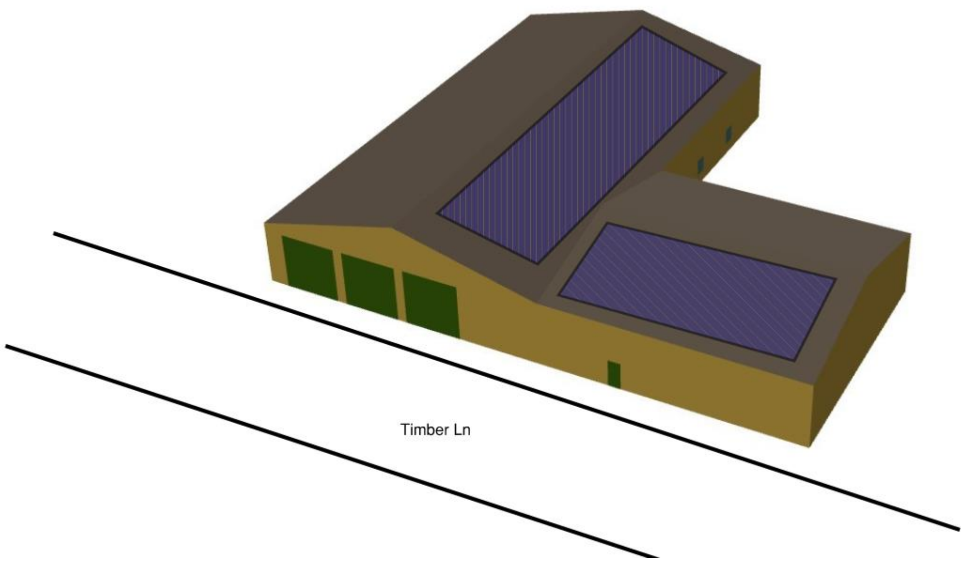

Figure 10 - Proposed Solar PV Panel Locations

Table 23: Solar PV (Only) Analysis Results

System Size (kW)	Electricity Generation (kWh)	Electricity Savings ($)	Implementation Costs ($)	Payback (Yrs)
57	70,892	9,847	210,000	21.3

[10] Azimuth is defined as the horizontal angle relative to true South.

4.5.3 Analysis of Option

Although roof mounted is presented in the bundle, comparable electricity offsets and implementation costs would apply for a ground mounted array using nearby available land. However, the total system size would still be limited to a maximum of 100 kW due to the Renewable Energy Act. This option features all of the advantages of Option 4, with additional investment and benefits from solar PV. A summary of these pros and cons is presented in the table below.

Table 24: Option 5 - Advantages & Disadvantages

Advantages	Disadvantages
• Lowest annual energy costs. • Lowest GHG emissions. • High potential for even lower emissions as grid becomes cleaner. • Attractive payback from incremental investment.	• High implementation costs. • Larger generator required (electric heating system).

Table 25: Comparison of Option 5 to Baseline

Option	Propane Consumption (L)	Electricity Consumption (kWh)	Peak Electrical Demand (kW)	Energy Costs ($)	Emissions (tCO_2)	Implementation Costs ($)
Baseline (Option 1)	23,560	75,088	22.0	37,753	57.7	222,000
Option 5	**0**	**116,749**	**87.8**	**24,872**	**35.0**	**435,000**

4.6 Option 5a - Maximizing Net Metering Solar Array Size

This addition to Option 5 explores the full utilization of Prince Edward Island's Renewable Energy Act regarding net metering, which allows renewable energy systems up to 100 kW AC in size. It is important to note that In 2021, Maritime Electric modified their Net Metering Program stipulating that systems above 30 kW must be connected to a three-phase power supply. Furthermore, construction of any net metered renewable energy system cannot start until the net metering agreement is approved by Maritime Electric. The utility provider cautions customers that it may take up to 3 - 4 weeks for an application to be processed. Under the Net Metering Program, excess electricity generation is credited monthly and can be carried forward for up to 12 months; however, any unused credits expire after that period. For this reason, it is critical that the system's annual generation does not exceed the building's annual consumption. Preliminary energy modelling for the North Rustico Fire Hall indicates that even at the 100 kW system size, this will not be an issue, making this a viable and impactful strategy for reducing long-term energy costs and emissions. An optimally positioned 100 kW array in North Rustico would generate approximately 138,591 kWh, offsetting roughly $19,243 of electricity costs annually. A system of this size would measure roughly 5,000 square feet, have an estimated implementation cost of $330,000, resulting in a simple payback period of 17 years.

This option considers two configurations: a mono-pitch roof design oriented south to maximize solar exposure and panel density, and a ground-mounted array on adjacent municipal land, which offers flexibility in layout and ease of maintenance. An image of what these two systems could look like is provided below.

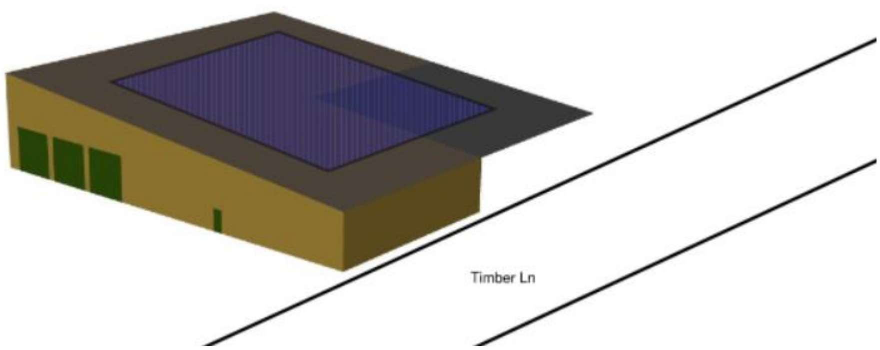

Figure 11 - Mono Pitched Roof Concept

Figure 12 - Ground-Mounted Array, Potential Site Layout

4.7 Option 6 - Geothermal Heat Pumps

4.7.1 Description of Systems

A geothermal heat pump system for space heating would be similar in design to Options 2 - 4, however, rather than being air sourced these heat pumps would recover heat from groundwater wells drilled approx. 150 ft underground. This system configuration would use the pumped groundwater to provide heat to ducted heat pumps, then return the now cooler water to the ground (the water becomes warmer in summer). A geothermal system could also be implemented to serve an in-floor heating distribution. Backup heating is not required for this option as the ground source is stable year-round and is unaffected by air conditions.

As discussed in the preliminary options report, there were initial concerns regarding the proximity of the proposed site to the prohibited well drilling area designated by the province. Following discussions with the province, it has been determined that this prohibited well drilling area is there to protect the current municipal wellfield in North Rustico. In order to drill a well at this location, a well permit application must be submitted to the Provincial Government for approval. Given the facility is a municipal building that would have been connected to the municipal network regardless, it is likely that the permit approval would be granted.

4.7.2 Analysis of Option

This option has the potential for even better efficiency than an air sourced heat pump system due to the higher source temperatures during very cold days of the year. However, these systems do have a higher implementation cost relative to the air source systems presented, it would likely require an additional 40 - 50k of capital to implement this approach. However, the drilling costs could be largely offset if the town is planning on drilling additional wells to provide for rapid filling of the fire trucks, the geothermal system would derive its source from this, and only a return well would be needed. North Rustico has expressed interest in high capacity wells on site, as they currently have to notify the water utility when filling their trucks, often prolonging the time it takes to complete this process. A summary of these pros and cons are presented in the table below.

Table 26: Option 6 - Advantages & Disadvantages

Advantages	Disadvantages
• Low annual energy costs. • Low GHG emissions. • High potential for even lower emissions as grid becomes cleaner. • Can draw source from fire truck refill well, if planned.	• Higher implementation costs. • Larger generator required (electric heating system).

Table 27: Comparison of Geothermal to Baseline

Option	Propane Consumption (L)	Electricity Consumption (kWh)	Peak Electrical Demand (kW)	Energy Costs ($)	Emissions (tCO_2)	Implementation Costs ($)
Baseline (Option 1)	23,560	75,088	22.0	37,753	57.7	222,000
Option 6	**0**	**190,533**	**66.2**	**35,031**	**57.2**	**291,300**

5 POINTS OF INTEREST

The following Points of Interest (POI) are presented for discussion. These items are additional considerations have been explored in tangent to the proposed options.

5.1 Landfill Methane Recovery

The site's existing history as a landfill presented initial thoughts that methane recovery may be a feasible form of energy recovery for the facility. The potential opportunity identified was to extract methane gas that would have leached into surrounding soil and to use this gas for combustion heating. Upon further investigation of the site, it is understood that this location was used more as a dumping pit for solid waste. EastPoint has determined that this site does not have rich enough methane deposits to be exploited as a feasible source of heat recovery for the proposed facility.

5.2 Wastewater Treatment Plant Methane Recovery

The proposed site is located directly next to a wastewater treatment plant that is also owned by the Town of North Rustico. The discussion of landfill methane recovery was taken a step further to discuss whether the same concept of methane recovery could be applied to the wastewater treatment plant. Upon deeper review, this option would require significant investment to re-design the process to include an anaerobic digester with methane recovery. If there is an appetite to further develop potential methane gas recovery at the wastewater treatment plant, further discussions should occur during evaluation of the wastewater plant's overall building condition to determine the most impactful areas of investment for this site.

5.3 Future-Minded Design

A key theme throughout the mechanical systems analysis for the proposed North Rustico Fire Hall has been future-minded design - ensuring that today's decisions do not limit tomorrow's opportunities. Many of the recommended configurations and considerations were selected with the goal of "future-proofing" the facility, allowing for seamless integration of emerging technologies and system upgrades over the building's lifecycle. For example, electrical infrastructure has been sized with sufficient capacity to accommodate future additions such as electric vehicle charging stations, expanded solar PV arrays, or advanced HVAC systems. Similarly, the inclusion of low-temperature hydronic distribution systems or adaptable forced air systems ensures compatibility with a wide range of future heat sources, including high-efficiency heat pumps, biomass boilers, or even waste heat recovery from the adjacent wastewater treatment plant. These design choices provide the Town with flexibility to respond to evolving energy technologies, funding opportunities, and climate goals, while minimizing the need for costly retrofits or structural modifications in the future.

6 CONCLUSION & RECOMMENDATIONS

6.1 Energy Consumption Summary

The following table presents the energy modelling results and estimated implementation costs for all five options and the geothermal Point of Interest (POI).

Table 28: Summary of Consumption from Proposed Options

Option	Fuel Consumption (ekWh)	Electricity Consumption (kWh)	Electrical Demand[11] (kW)	Energy Costs ($)	Implementation Costs ($)	Emissions (tCO_2)
1	167,820	75,088	223.4	37,753	222,000	57.7
2	104,503	102,084	279.8	33,436	225,000	52.5
3	135,904	89,394	266.7	31,320	303,500	70.3
4	0	184,411	559.0	34,986	240,000	55.3
5	0	132,305	559.0	24,872	435,000	35.0
6	0	190,533	532.1	35,031	291,300	57.2

6.2 Energy Savings Summary

Option 1 is the highest energy consuming option analyzed within this study. As such, energy reductions beyond the consumption proposed in Option 1 can be analyzed as being "savings" from this baseline. All costs exceeding Option 1 (baseline costs) can be treated as incremental costs to achieve these energy savings. This allows for payback analysis of each incremental investment to even further assess feasibility.

Table 29: Summary of Savings from Option 1 (Baseline)

Option	Fuel Savings (ekWh)	Electricity Savings (ekWh)	Demand Savings (kW)	Energy Costs Savings ($)	Incremental Costs ($)	Simple Payback (Yrs)	Emission Reduction (tCO_2)
1 (Baseline)	-	-	-	-	-	-	-
2	63,317	-26,996	-56	4,317	3,000	0.7	5.2
3	31,916	-14,306	-43	6,433	81,500	12.7	-12.6
4	167,820	-109,323	-336	2,767	18,000	6.5	2.4
5	167,820	-41,661	-336	12,882	213,000	16.5	35.0
6	167,820	-115,445	-309	2,723	69,300	25.5	0.6

[11] Annual electrical demand is forecasted by totalizing peak electrical demand of every month within energy modelling software.

6.3 Ranking of Options

In order to do a quantitative comparison of each option analyzed within this study, each option was ranked from most favourable (6) to least favourable (1) based on the following criteria: GHG emissions, implementation costs, annual energy costs, and payback (from incremental investment). This evaluation helps determine which option/investment will be the most impactful and economical for the facility. The most favourable options using this analysis have been highlighted green.

Table 30: Ranking of Measures Based on Metrics

Option	Emissions Ranking	Implementation Costs Ranking	Energy Costs Ranking	Payback Ranking	Sum of Rankings
1	3	5	1	-	9
2	**5**	**4**	**4**	**4**	**17**
3	1	2	5	3	11
4	**4**	**4**	**3**	**5**	**16**
5	**6**	**1**	**6**	**2**	**15**
6	3	3	2	1	9

6.4 Recommendations

Based on the analysis of estimated implementation costs, annual energy consumption, advantages & disadvantages, **EastPoint recommends Option 5** consisting of ducted heat pumps with backup electric, heat recovery ventilation, and solar photovoltaic be pursued for the proposed facility. Given this option is fully electric, emissions are expected to be reduced even further than projections made in this report as the electricity grid becomes less emission intense.

If the Town is planning to install high-capacity wells on site for rapid fire truck filling, **EastPoint also recommends strong consideration of the geothermal system**, as it can leverage the same well infrastructure for its heat source. This system is also fully electric, offering all the same long-term emissions and energy cost benefits as Option 5, with only a modest increase in upfront investment.

If the Town of North Rustico would rather have on-site combustion for heating to reduce generator requirements and overall implementation costs, **EastPoint recommends Option 2 as low-cost alternative.**

If the Town of North Rustico is looking to phase the investments for this facility, it could always consider implementing solar photovoltaic in the immediate years following construction. If implementation is pursed in phases, it is critical that future PV plans are well communicated during phase 1 to ensure electrical and structural provisions can be made during the phase 1 detailed design of the facility.

6.5 Study Limitations

This report was prepared by EastPoint on behalf of the Canadian Urban Institute for the Town of North Rustico. The material in it reflects our professional judgment in light of the following:

- Our interpretation of the objective and scope of works during the study period;
- Information available to us at the time of preparation;
- Third party use of this report, without written permission from EastPoint, is the responsibility of such third party; and

- Measures identified in this report are subject to the professional engineering design process before being implemented.

The savings calculations are our estimate of saving potentials and are not guaranteed. The impact of building changes in space functionality, usage, equipment retrofits, and weather need to be considered when evaluating the savings.

Any use which a third party makes of this report, or any reliance on decisions to be made are subject to interpretation. Client accepts no responsibility or damages, if any, suffered by any third party as a result of decisions made or actions based on this report. In the next stage it is recommended that, for the implementation of the measures proposed in this report, detailed design documents be developed.

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